Bi-Layer" at a 0.2 volt demand for transient times of 50 milliseconds at reference numeral 74, for 100 milliseconds at reference numeral 76, and for 200 milliseconds at reference numeral 78. A rated current density of a typical PEM cell for a transportation vehicle is about 500 ASF (amps/ft^2). A contact bi-layer with a 25 percent hydrophilic mixture therefore would have an enhanced transient current density capability of approximately 125 ASF for 100 millisecond of current demand, which is equal to about one-quarter a steady state load of the cell.

An electrochemical cell constructed in accordance with the above disclosure will significantly enhance fluid transport throughout the cell while also increasing capacitance of the cell thereby maintaining an efficient water balance so that the risk of the anode electrode 36 drying out or the cathode electrode becoming flooded at high current output is minimized. Consequently, an electrochemical cell such as the fuel cell **10** utilizing porous support plates **40**, **42** of the present invention will substantially increase effective and transient current output capacity of the cell **10** without a proportionate increase in size, weight and cost of the cell.

While the present invention has been described and illustrated with respect to a particular construction and method of manufacture of an electrochemical cell with a porous support plate, it is to be understood that the present invention is not limited to the described and illustrated examples. For example, the first and second porous support plates **40**, **42** have been described and shown adjacent to the anode and cathode electrodes 36, 38. However it is possible that they may be separated from each other by intermediary layers (not shown), but the first porous support plate **40** would remain in fluid communication with the anode electrode **36**, and the second porous support plate would remain in fluid communication with the cathode electrode **38**. Accordingly, reference should be made primarily to the attached claims rather than the foregoing description to determine the scope of the invention.

What is claimed is:

1. An electrochemical cell, comprising
   a. an electrolyte held within a porous non-conductive matrix having a first major surface and an opposed second major surface;
   b. an anode electrode supported in intimate contact with the first major surface and a cathode electrode supported in intimate contact with the second major surface; and
   c. at least one porous support plate including a contact bi-layer adjacent the anode or cathode electrode supported on a porous substrate layer, wherein the contact bi-layer includes hydrophobic phase means for facilitating gas transfer and for restricting liquid absorption through a network of hydrophobic gas passages integrated throughout the contact bi-layer and the contact bi-layer also includes hydrophilic phase means for facilitating liquid transfer through a network of hydrophilic liquid passages integrated throughout the contact bi-layer, and for increasing capacitance of the cell.

2. The electrochemical cell of claim 1, wherein the hydrophobic phase means includes hydrophobic gas passages defined by a mixture of carbon black and a hydrophobic polymer and the hydrophilic phase means includes hydrophilic liquid passages defined by a mixture of carbon black and a proton exchange resin.

3. The electrochemical cell of claim 2, wherein the mixture of carbon black and a hydrophobic polymer comprises a mixture of about thirty-five to sixty-five weight per cent of a high structure carbon black and about sixty-five to thirty-five weight per cent of the hydrophobic polymer.

4. The electrochemical cell of claim 3, wherein the mixture of carbon black and a proton exchange resin includes about thirty to seventy weight per cent of a low structure, high surface area carbon black and about seventy to thirty weight per cent of the proton exchange resin.

5. The electrochemical cell of claim **4**, wherein the contact bi-layer includes about fifty to eighty per cent by volume of the hydrophobic phase means and about fifty to twenty per cent by volume of the hydrophilic means.

6. The electrochemical cell of claim 5, wherein the substrate layer includes discrete hydrophobic regions and discrete hydrophilic regions wherein the hydrophobic regions include hydrophobic compounds to facilitate gas transfer and restrict liquid absorption through the hydrophobic regions.

7. The electrochemical cell of claim **6**, wherein the cell is a fuel cell and the electrolyte is a proton exchange membrane.

8. A fuel cell for producing electrical energy from reactant and oxidant fluids, comprising:
   a. a proton exchange membrane having a first major surface and an opposed second major surface;
   b. an anode electrode supported in intimate contact with the first major surface and a cathode electrode supported in intimate contact with the second major surface; and,
   c. at least one porous support plate including a contact bi-layer in fluid communication with the anode or cathode electrode supported on a porous substrate layer, wherein the contact bi-layer includes a hydrophobic mixture that defines a network of hydrophobic gas passages integrated throughout the contact bi-layer for facilitating gas transfer and for restricting liquid absorption and the contact bi-layer also includes a hydrophilic mixture that defines a network of hydrophilic liquid passages integrated throughout the contact bi-layer for facilitating liquid transfer, and for increasing capacitance of the cell.

9. The fuel cell of claim **8**, wherein the hydrophobic mixture further comprises a mixture of carbon black and a hydrophobic polymer and the hydrophilic mixture further comprises a mixture of carbon black and a proton exchange resin.

10. The fuel cell of claim **9**, wherein the mixture of carbon black and a hydrophobic polymer further comprises a mixture of about thirty-five to sixty-five weight per cent of a high structure carbon black and about sixty-five to thirty-five weight per cent of the hydrophobic polymer.

11. The fuel cell of claim **9**, wherein the mixture of carbon black and a proton exchange resin further comprises about thirty to seventy weight per cent of a low structure, high surface area carbon black and about seventy to thirty weight per cent of the proton exchange resin.

12. The fuel cell of claim **8**, wherein the contact bi-layer includes about fifty to eighty per cent by volume of the hydrophobic mixture and about fifty to twenty per cent by volume of the hydrophilic mixture.

13. The fuel cell of claim **8**, wherein the porous substrate layer includes discrete hydrophobic regions and discrete hydrophilic regions wherein the hydrophobic regions include hydrophobic compounds to facilitate gas transfer and restrict liquid absorption through the hydrophobic regions.

14. The fuel cell of claim **8**, wherein the porous substrate layer includes a wettability preserving compound so that a pressure differential between a coolant liquid water supplied through a water transport plate and the reactant fluid displaces most liquid water from pores within the substrate to facilitate gas transfer and retain some liquid water transfer through the substrate layer.

* * * * *

15. A fuel cell, comprising:

an anode support plate and a cathode support plate and a membrane electrode assembly disposed between said anode and cathode support plates, said membrane electrode assembly comprising a polymer electrolyte membrane, one of said support plates comprising a hydrophilic substrate layer having pores therein;

a water transport plate adjacent to each said hydrophilic substrate layer, said water transport plate having a passageway for a coolant stream and another passageway for a reactant gas stream; and

means for creating a pressure differential between said reactant gas stream and said coolant stream such that the pressure of said reactant gas stream is higher than the pressure of said coolant stream.

16. A fuel cell according to claim 15 wherein:

said pressure differential is between 2 psi and 3 psi.

17. A fuel cell, comprising:

an anode support plate and a cathode support plate and a membrane electrode assembly disposed between said anode and cathode support plates, said membrane electrode assembly comprising a polymer electrolyte membrane, at least one of said support plates comprising a hydrophilic substrate layer having pores therein;

a water transport plate adjacent to each said hydrophilic substrate layer, said water transport plate having a passageway for a coolant stream and another passageway for a reactant gas stream; and

each said at least one support plate comprising a partially hydrophobic bilayer disposed between said hydrophilic substrate layer and said membrane electrode assembly.

18. A fuel cell according to claim 17 wherein:

said bilayer includes 50% to 80% by volume of hydrophobic phase material, and between 50% and 20% by volume of hydrophilic phase material.

19. A fuel cell, comprising:

an anode support plate and a cathode support plate and a membrane electrode assembly disposed between said anode and cathode support plates, said membrane electrode assembly comprising a polymer electrolyte membrane, at least one of said support plates comprising a hydrophilic substrate layer having pores therein;

a water transport plate adjacent to each said hydrophilic substrate layer, each said water transport plate having a passageway for a coolant stream and another passageway for a reactant gas stream; and

each said one substrate layer having a porosity of between 65% and 75%.

20. A method of operating a fuel cell comprising an anode support plate and a cathode support plate and a membrane electrode assembly disposed between said anode support plate and said cathode support plate, said membrane electrode assembly comprising a polymer electrolyte membrane, at least one of said support plates comprising a hydrophilic substrate layer having pores therein, said fuel cell power plant comprising a water transport plate adjacent to each said hydrophilic substrate layer, said water transport plate having a passageway for a coolant stream and another passageway for a reactant gas stream;

characterized by:

creating a predetermined pressure differential between said reactant gas stream and said coolant stream such that the pressure of said reactant gas stream is higher than the pressure of said coolant stream.

21. A fuel cell according to claim 20 wherein:

the pressure of said reactant gas stream is between 2 psi and 3 psi higher than the pressure of said coolant stream.